

## Claims

1. A method of translating environmental forecast data to an operations data associated with providing electrical power produced from a renewable power generation facility to a power grid, comprising steps of:

5       sensing environmental factors that affect an amount of electrical power generated by the renewable power generation facility;

      developing an environmental forecast from said environmental factors sensed in said sensing step;

      committing to deliver at least a portion of a unit of power from said renewable power generation facility at a predetermined time; and

      developing a trading position for said unit of power based on an uncertainty in said environmental forecast.

2. The method of claim 1, further comprising steps of:

      calculating a financial risk associated with a commitment to deliver the unit of power at the predetermined time;

      contrasting a cost associated with a risk of failure to deliver the unit of power at the predetermined time with a cost to mitigate said risk of failure; and

      at least one of adjusting and not adjusting said trading position based on an  
20       uncertainty in an environmental reforecast made with an update in said environmental factors.

3. The method of claim 2, wherein said trading position includes trading an option to offset said uncertainty in said environmental reforecast.

4. A method for trading electrical power produced from a renewable power generation facility, comprising steps of:

forecasting at a predetermined time an amount of electric power output from said renewable power generation facility for delivery at a predetermined delivery time, wherein said electric power output is a function of an environmental condition when said electrical power is generated;

developing a trading position based on an environmental forecast uncertainty;

bidding on a futures contract on a power exchange for delivering a predetermined unit of power at a predetermined future time;

reforecasting said electric power output at another predetermined time closer to said predetermined delivery time than said predetermined time; and

adjusting said trading position based an uncertainty in an environmental reforecast developed in said reforecasting step.

5. A method for operating a power exchange options market, comprising steps of:

receiving bids for power units to be supplied to the power exchange options market;

exchanging power for energy held by a virtual energy storage mechanism;

compensating for a variation in power production by a renewable power generation facility by trading at least one of a standardized call option and a standardized put option on power produced by an other power producer; and

adjusting a threshold for trading the at least one of a standardized call option and a standardized put option based on an environmental forecast and an environmental forecast error prediction.

6. A method according to Claim 5, wherein:

the at least one of a standardized call option and a standardized put option is issued for a specific time period and a strike price,

the strike price is a spot price on the power exchange for the specific time period,

the standardized put option provides a trader of power from the renewable power generation facility with a contractual right to sell power production that exceeds an amount bid into the power exchange, and

the standardized call option provides the trader with a contractual right to buy power in order to meet an obligation in the power exchange.

7. A method according to Claim 6, wherein:

the at least one of a standardized call option and a standardized put option is sufficiently large to cover a predetermined unit of power.

8. A method according to Claim 5, further comprising a step of:

calculating a predetermined uncertainty in power production and trading a quantity of options to cover said predetermined uncertainty,

sending a signal to the power exchange to execute a trading deal if a deviation from a forecasted power production level with a forecast error probability is detected during the production time period, wherein

said forecast error probability is calculated with at least one of a statistical model, an estimation and an ensemble forecast.

9. A method according to Claim 5, further comprising steps of:

receiving buy, sell and trade bids and offers for call and put options;

ranking a buyer and a seller against predetermined criteria;  
closing a deal when a bid and an offer match;  
sending a transaction confirmation to a buyer and a seller; and  
settling respective accounts of said buyer and seller.

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10. A method according to Claim 5, further comprising a step of:  
reassessing an environmental forecast and a predicted power production level after an  
expected volume is bid on a spot market; and  
trading a unit of power from a renewable power facility on a balance market based on  
a reassessed environmental forecast until a closure of the balance market.

11. A method according to Claim 10, further comprising steps of:  
calculating a cost of unbalance after the balance market closes;  
determining a risk willingness of the renewable power supplier and a transmission  
constraint; and  
determining a number of options and a cost of options to be traded by the renewable  
power supplier based on said risk willingness.

12. A method according to Claim 11, wherein said determining a risk willingness  
step comprises  
calculating a cost of not being able to fulfil a bid production level on the spot  
exchange or in a bilateral contract,  
calculating lost revenue based on a likelihood that the delivery of renewable power  
cannot be fulfilled, and

calculating a financial situation of a supplier of the power from the renewable power generation facility.

13. A method according to Claim 10, further comprising a step of:

5 sending a signal to the power exchange if a deviation from a forecasted power production level is detected during the production time period;

determining if the renewable power supplier has enough options to compensate for the deviation;

calculating a level of regulation required by a seller of options for an affected time period; and

10 sending a regulation signal to the other power supplier.

14. A method according to Claim 13, further comprising a step of:

calculating a regulation potential of the other power supplier for a predetermined future time period.

15. A method according to Claim 14, wherein said calculating a regulation potential step includes substeps of:

calculating a future power generation capability level;

20 comparing a planned power production level for a future time period with a minimum and a maximum production level; and

contrasting a price level on the spot market with a price level on a futures market.

16. A method according to Claim 15, further comprising a step of:

determining a value of said regulation potential based on a total forecasted regulation need; and  
setting a price for regulation options.

5           17.     A method according to Claim 16, further comprising a step of:  
  
determining if a regulation option is needed; and  
  
determining if transmission rights are available for delivery of backup power to the  
grid on behalf of a renewable power production facility, wherein  
  
said backup power includes power from at least one of a virtual energy storage  
10       facility, a fuel cell, a heat storage system that includes at least one of a district heating system  
and a boiler feedwater system, and a compressed high pressure gas reservoir.

15           18.     A method according to Claim 17, further comprising a step of:  
  
calculating a maximum volume of issued options and a least wanted price;  
sending offers to the power exchange;  
issuing options hour by hour;  
settling option premiums between power exchange participants; and  
negotiating spot sales of power.

20           19.     A method for operating a bilateral options market, comprising steps of:  
  
compensating for a variation in power production by a renewable power generation  
facility by providing power from an other power production facility arranged by at least one  
of a bilateral contract and trading a bilateral option to trade power so as to meet an obligation  
for at least one of a specific renewable power generation facility and a set of renewable power  
25       generation facilities;

customizing the bilateral option to fulfill a need of the at least one of a specific renewable power generation facility and a set of renewable power generation facilities; and adjusting a strategy for trading the bilateral option based on a meteorological forecast and a meteorological forecast error prediction.

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20. A method according to Claim 19, further comprising a step of:  
receiving buy, sell and trade bids for bilateral options for the at least one of a specific renewable power generation facility and a set of renewable power generation facilities;  
ranking a buyer and a seller against predetermined criteria;  
closing a deal when a bids and an offer match;  
sending a transaction confirmation to a buyer and a seller; and  
settling respective accounts of said buyer and seller.

21. A method according to Claim 19, wherein:  
the bilateral option is issued for a specific time period and a strike price,  
the strike price is a spot price on the power exchange for the specific time period, and  
the put option provides a trader with a right to sell power that exceeds an amount bid into the power exchange, and  
the call option provides the trader with a right to buy power in order to meet an  
20 obligation in the power exchange.

22. A method according to Claim 21, wherein:  
the at least one of the call option and the put option is sufficiently large to cover a predetermined unit of power.

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23. A method according to Claim 21, further comprising a step of:

calculating a predetermined uncertainty in power production and trading a quantity of options to cover said predetermined uncertainty.

24. A method according to Claim 23, further comprising steps of:

receiving buy, sell and trade bids and offers for call and put options;

ranking a buyer and a seller against predetermined criteria;

closing a deal when a bid and an offer match;

sending a transaction confirmation to a buyer and a seller; and

settling respective accounts of said buyer and seller.

25. A method according to Claim 23, further comprising a step of:

reassessing an environmental forecast and a predicted power production level after an expected volume is bid on a spot market; and

trading a unit of power from a renewable power generation facility on a balance market based on a reassessed environmental forecast until a closure of the balance market.

26. A method according to Claim 25, further comprising steps of:

calculating a cost of unbalance after the balance market closed;

determining a risk willingness of the renewable power supplier and a transmission constraint; and

determining a number of options and a cost of options to be traded by the renewable power supplier.



27. A method according to Claim 26, wherein said determining a risk willingness step comprises

calculating a cost of not being able to fulfil a bid production levels on the spot exchange or in a bilateral contract,

calculating lost revenue based on a likelihood that the delivery of renewable energy cannot be fulfilled, and

calculating a financial situation of a supplier of the power from power from the renewable power generation facility.

28. A method according to Claim 27, further comprising a step of:

sending a signal to the bilateral exchange if a deviation from a forecasted power production level with a forecast error probability is detected during the production time period;

determining if a supplier of power from the renewable power production facility has enough options to compensate for the deviation;

calculating a level of regulation required by a seller of options for an affected time period; and

sending a regulation signal to the other power supplier, wherein

said forecast error probability is calculated with at least one of a statistical model, an estimation and an ensemble forecast.

29. A method according to Claim 28, further comprising a step of:

calculating a regulation potential of the other power supplier for a predetermined future time period.

30. A method according to Claim 29, wherein said calculating a regulation potential step includes substeps of:

- calculating a future power generation capability level;
- comparing a planned power production level for a future time period with a minimum and a maximum production level; and
- contrasting a price level on the spot market with a price level on a futures market.

31. A method according to Claim 30, further comprising a step of:

- determining a value of said regulation potential based on a total forecasted regulation need; and
- setting a price for regulation options.

32. A method according to Claim 31, further comprising a step of:

- determining if a regulation option is needed; and
- determining if transmission rights are available for delivery of backup power to the grid on behalf of a renewable.

33. A method according to Claim 32, further comprising a step of:

- calculating a maximum volume of issued options and a least wanted price;
- sending offers to the power exchange;
- issuing options hour by hour;
- settling option premiums between power exchange participants; and
- negotiating spot sales of power.

34. A method for mitigating risk across a power grid, comprising steps of:

calculating a summed power production differential for a set of renewable and non-renewable power generation facilities on the power grid;

contrasting the summed power production differential with a predetermined level of grid power production differential coupled to a predetermined acceptable level of grid frequency fluctuation; and

executing at least one of a predetermined production action with an other power producer and a predetermined load shedding action with a consumer, wherein

the summed power production differential includes a transmission limitation and a transmission loss.

35. A method for operating a renewable power prediction market, comprising steps of:

receiving requests for a dataset about at least one of a renewable power generation facility and a set of renewable power generation facilities;

reading data from a power prediction market database;

retrieving environmental data;

forecasting renewable energy levels; and

calculating an environmental forecast error.

36. A method according to Claim 35, wherein:

said dataset includes at least one of location, power production capacity and existing backup power arrangements; and

said power prediction market database comprises data provided from at least one of a local renewable power supplier environmental sensor, a nearby renewable power supplier

environmental sensor, a network of environmental sensors, and a national meteorological facility.

37. A method according to Claim 35, further comprising steps of:

retrieving financial data from a power exchange;

forecasting a power production traded on a power exchange and a production forecast error distribution;

calculating a monetary value of the production forecast error distribution;

providing a monetary value of a forecast production report and a related error; and

collecting a fee for said monetary value of forecast production report.

38. A method according to Claim 37, wherein:

said calculating step comprises a substep of identifying an expected value of power to be produced at a predetermined future time by identifying an expected value of a probability density function of a market production, weighted with a value of a amount of power to be produced at said predetermined future time;

said providing step comprises a substep of delivering by at least one of e-mail, web posting, telephone and postal mail; and

said collecting step comprises a substep of periodically issuing a subscription fee.

39. A computer-based system for reducing financial risk for a renewable power generation facility, comprising:

a computer bus;

a central processor connected to the computer bus;

an environmental forecasting mechanism connected to the computer bus;

an environmental forecast error determination mechanism connected to the computer bus and configured to estimate an environmental forecast error;

a power production prediction mechanism connected to the computer bus and configured to predict an amount of power output by a renewable facility at a predetermined future time;

a computer-based program hosted in the central processor and configured to combine the environmental forecast error with pricing data for a unit of power offered on the power exchange;

a risk assessment mechanism connected to the computer bus and configured to assess a financial risk associated with using forecast data from the environmental forecasting mechanism to make production predictions for electrical power produced by the renewable power generation facility; and

an external interface configured to exchange information and results to external devices.

40. A computer-based system for reducing financial risk for a renewable power generation facility of claim 39, further comprising:

a risk minimization and insurance mechanism configured to provide options for minimizing risk associated with renewable power production financial strategies.

41. A computer-based system according to Claim 39, wherein:  
the external interface is configured to connect to different entities comprising at least one of a renewable exchange, a power exchange, and an investor;

the risk assessment mechanism is configured to receive an output from the power production prediction mechanism in a form of a statistical description of a likelihood of predetermined levels of power production from the renewable facility over a period of time;

the power production prediction mechanism is configured to provide a related expected price to be paid for power sold in an open market system comprising at least one of a renewable exchange and a power exchange; and

the risk minimization and insurance coordination mechanism is configured to maintain a statistical accuracy of previous environmental forecasts, to prompt a user of the risk minimization and insurance mechanism to determine whether insurance is desired and to offer to offset a financial risk associated with a faulty forecast.

42. A computer-based system according to Claim 39, wherein:

the risk minimization and insurance coordination mechanism includes an automated feature configured to guard against a risk of legal liability should a cause of action be raised against the forecaster for providing faulty information, when a user of the risk minimization and insurance mechanism has determined that insurance should be obtained either for an investor or a forecaster.

43. A computer-based system according to Claim 39, wherein:

the risk minimization and insurance coordination mechanism is configured to coordinate a contract with another energy provider so as to provide supplementary energy in a case that a renewable power production is below a previously predicted level.

44. A renewable power prediction database, comprising:

a memory having data fields, one of said data fields including a data structure containing data descriptive of at least one of local renewable power production capabilities and status, a competitors power production capabilities and status, a predicted grid capacity, and a grid capacity expansion needs, wherein

5 a content of said data structure being included in a signal communicated to a processor for coordinating power production levels of a renewable power generation facility and another power generation facility.

45. A database according to Claim 44, wherein:  
40 said data structure includes a field including an identity of said renewable power production facility.

46. An apparatus for translating environmental forecast data to an operations data associated with providing electrical power produced from a renewable power generation  
15 facility to a power grid, comprising:

a computer bus;

a central processor;

an environmental forecasting mechanism;

a risk assessment mechanism connected to the computer bus and configured to assess

20 a financial risk associated with using forecast data from the environmental forecasting mechanism to make production predictions for electrical power produced by the renewable power generation facility;

means for sensing environmental factors that affect electrical power generated by the renewable power generation facility;

means for developing an environmental forecast based on statistical information from said environmental factors sensed by said means for sensing;

means for committing to deliver a portion of a unit of power from said renewable power generation facility at a predetermined time; and

5 means for developing a trading position for said unit of power based on an uncertainty in said environmental forecast.

47. An apparatus for trading electrical power produced from a renewable energy power producer, comprising:

10 a computer bus;  
a central processor;  
an environmental forecasting mechanism;  
a risk assessment mechanism connected to the computer bus and configured to assess a financial risk associated with using forecast data from the environmental forecasting  
15 mechanism to make production predictions for electrical power produced by the renewable power generation facility;

means for forecasting at a predetermined time an electric power output from said renewable energy power producer for delivery at a predetermined delivery time, wherein said electric power output is a function of an environmental condition when said electrical power  
20 is generated;

means for developing a trading position based on an environmental forecast uncertainty;

means for bidding on a futures contract on a power exchange for a predetermined unit of power at a predetermined future time;



means for reforecasting said electric power output at another predetermined time closer to said predetermined delivery time than said predetermined time; and

means for adjusting said trading position based an environmental reforecast uncertainty.

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48. An apparatus for operating a power exchange options market, comprising:

a computer bus;

a central processor;

an environmental forecasting mechanism;

a risk assessment mechanism connected to the computer bus and configured to assess a financial risk associated with using forecast data from the environmental forecasting mechanism to make production predictions for electrical power produced by the renewable power generation facility;

means for receiving bids for power units to be supplied to the power exchange options market;

means for exchanging power for energy held by a virtual energy storage mechanism;

means for compensating for a variation in power production by a renewable power generation facility by trading at least one of a standardized call option and a standardized put option on power produced by an other power producer; and

means for adjusting a threshold for trading the at least one of a standardized call option and a standardized put option based on an environmental forecast and an environmental forecast error prediction.

49. An apparatus for operating a bilateral options market, comprising:

a computer bus;

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a central processor;

an environmental forecasting mechanism;

a risk assessment mechanism connected to the computer bus and configured to assess  
a financial risk associated with using forecast data from the environmental forecasting  
mechanism to make production predictions for electrical power produced by the renewable  
power generation facility;

means for compensating for a variation in power production by a renewable power  
generation facility from an other power producer by trading at least one of a bilateral option  
to trade power to meet an obligation for at least one of a specific renewable power generation  
facility and a set of renewable power generation facilities;

means for customizing the at least one of a bilateral option to fulfill a need of the at  
least one of a specific renewable power generation facility and a set of renewable power  
generation facilities; and

means for adjusting a strategy for trading the at least one of a bilateral option based on  
a meteorological forecast and a meteorological forecast error prediction.

50. An apparatus for mitigating risk across a power grid associated with renewable  
power sources, comprising:

a computer bus;

a central processor;

an environmental forecasting mechanism;

a risk assessment mechanism connected to the computer bus and configured to assess  
a financial risk associated with using forecast data from the environmental forecasting  
mechanism to make production predictions for electrical power produced by the renewable  
power generation facility;

means for calculating a summed power production differential for a set of renewable and non-renewable power generation facilities on the power grid;

means for contrasting the summed power production differential with a predetermined level of grid power production differential coupled to a predetermined acceptable level of grid frequency fluctuation; and

means for executing at least one of a predetermined production action with an other power producer and a predetermined load shedding action with a consumer.

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